Physicochemical characteristics of Syrian Buffalo (*Bubalus bubalis*) milk

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Abstract

This study aims to estimate the values of Syrian buffalo milk components, and the correlations between them, and to study the effect of some environmental factors on milk components. The study was conducted on Syrian buffalo at Shatiha station, Al-Ghab plain, Hama governorate. Thirty milking buffaloes were randomly selected to collect milk samples immediately after milking. Then it was taken to a laboratory to estimate some of the components of milk. The values for fat (F%), protein (PRO%), lactose (LAC%), non-fat solids (NFS%), ash%, and density of milk (DE), g/cm^3 were 6.13±0.19, 3.41±0.05, 4.36±0.07, 8.57±0.12, 0.77±0.01, 1.027±0.0003, respectively. NFS% was affected by parity, F%, and PRO% by month of calving, and F%, PRO%, and DE by milk period. The correlations between LAC%, PRO%, ash%, and DE were positive and highly significant. The correlation between NFS% and ash% was positive and significant, as well as between PRO% and DE. This research concluded that components of milk could be improved by providing better care of the Syrian buffalo herd and balanced nutrition throughout the milking period. In addition, raising energy and coarse feed levels in the diet increased milk content and improved LAC% and F%, especially during the late milking period.

Keywords: Buffaloes; Fat; Protein; Lactose; Non-Fat Solids; Ash; Milk density.

Introduction

Buffaloes (Bubalus bubalis) in Asia make up more than 95% of the world total buffalo population (Borghese and Mazzi, 2005). The buffaloes can adapt to different agro-climatic zones and are source of milk and rural livelihood in arid region of India (Patel et al 2016) to Hilly regions of Nepal (Gautam et al 2021). Although there is no reliable census of Syrian buffaloes due to civil war, the population has been estimated to be nearly eight thousand according to FAO (2018). The buffalo's strong body structure and resistance to diseases have made it important for livestock in Syria, especially in the countryside of Hama (Elsayed et al 2020). The countryside of Hama governorate was famous for rearing Syrian buffalo, as there were ponds on the banks of Orontes River suitable for their care. Syrian buffalo care is a source of livelihood for breeders who depend on their milk and meat.

Fig 1: Photographs of the males and females of Syrian buffalo.

Milk has high nutritional value. Therefore, it is one of the most important foods for growing children due to its essential components (Javaid et al 2009). To ensure the milk quality, its contents of fat and non-fat solids are determined. With the availability of a milk analyzer, it has become possible to measure milk components, such as fat, protein, lactose, ash, non-fat solids, and density. The characteristics of milk components are essential for buffalo farmers to maintain the price of raw milk (Malek dos Reis et al 2013).

Buffalo milk is rich in solids of high value; fat and protein are among the major milk solids that are very important in different manufacturers, such as the production of mozzarella cheese (Tonhati et al 2011). Lately, it is well observed that there is an increasing demand for buffalo milk, because of its high fat, good calcium content, and low cholesterol percentage (Bilal et al 2006); Moreover, it is convenient production in terms of quality, and sustainability (Andrea et al 2011).

Many factors influence the percentage of buffalo milk components, such as milk stage, feed, and pasture availability, which play an essential role in the quality of their products. This research planned to estimate components and correlations for variables of raw buffalo milk and to study some non-genetic factors at Shatiha station under a semi-intensive system in Al-Ghab Plain, Syria.

Material and Methods

The Buffalo Herd in Al-Ghab Plain

Al-Ghab Plain in northwest Syria is a productive lowland area measuring 63×12.1 km, with the Orontes River running northward through it. The river waters have created a marshland that lasted for centuries. The Al-Ghab project was launched in the previous century to convert the plain into arable land, creating 41,000 hectares of irrigated agricultural fields. It is located at latitude 35 and longitude 62, rises 270 m above sea level, and experiences mild weather with four distinct seasons.

At Shetiha station, buffaloes are kept freely in semi-open yards, where adult animals are permitted to graze all day within the station fence. The buffaloes go out to pastures in the morning till the evening, napping in a water pool from 11 am to 4 pm to escape the high summer heat. On cold winter nights and during bad weather, they are housed in semi-open concrete sheds. At the station, wheat or corn bran fodder, hulled cotton meal, barley, wheat hay, fodder beet, barley hay-vetch, and pasture herbs are available to feed buffaloes according to their physiological condition. On average, buffaloes eat 20 kg of green fodder daily while grazing in the pasture. In addition to that, they are given 4 kg of hay, 2 kg of barley-vetch hay, and 2 kg of fodder beets. The concentrated feeds that are available - barley, corn, hulled cottonseed, and wheat bran - provide a mixture containing 12.3% protein and 64.1% TDN. Water was available to the buffaloes at all times.

The Samples and Chemical Analysis

420 raw milk samples were collected twice a day every two weeks, immediately after milking from 30 randomly selected female buffaloes at Shatiha station throughout the milking period in 2018. 250 mL of milk samples were taken under sterile conditions and transferred into a laboratory at 4ºc, then analyzed by a milk scan apparatus. Percentages of fat (F%), protein (PRO%), lactose (LAC%), non-fat solids (NFS%), ash%, and milk density DE (g/cm^3) of milk samples were recorded.

Statistical Analysis

Data were statistically analyzed using SAS (2012) program according to General Linear Model to determine non-genetic factors that affect components of milk yield according to the following model:

$$Y_{ijkl} = \mu + PR_i + CM_j + MP_K + e_{ijkl}$$

Where, Y_{ijkl} = F%, PRO%, LAC%, NFS%, ash%, and milk density DE (g/cm^3) of $ijkl^{th}$ record. μ = grand mean, PR_i = effect of kth parity coded as k = 1, 2 and 10+, respectively. CM_j = effect of ith calving month coded as j = 3, 4 … and 7+. MP_K = effect of kth milk production period coded as j = 1, 2, and 3 of early (5 to 90 days), middle (91 to 180 days), and late (over 181 days to dry), respectively. e_{ijkl} = random error term associated with the Y_{ijkl} observation with zero mean and variance $I\sigma^2$e. Duncan multiple range test was used to detect differences between means of effects (Duncan, 1955). In addition, a correlation analysis between the studied milk contents was performed.

Results and Discussions

According to a personal communication, the daily and total milk yield of this herd is estimated to be 4.0 and 764 kg, respectively, during a lactation period of 190 days. NFS% were affected by parity (PR), while F%, PRO%, LAC%, ash%, and DE (g/cm^3) were not affected (Table 1). These results are in good agreement with the previously reported by Choodamani et al (2018). While Verma et al (2016) showed that F% and NFS% were non significantly affected by parity.

Table (1) shows that calving month (CM) had significant effects on both F% and PRO% and was not significant for LAC%, NFS%, ash%, and DE. Zeki et al (2013) stated consistent results for the effect of CM on PRO%, and F%, and inconsistent on LAC%, NFS% and ash%. As well as Chitra et al (2016) confirmed that NFS% was not affected by CM.

Milk period (MP) was highly significant on F%, LAC%, and DE while PRO%, NFS%, and ash% had no effects (Table 1). Choodamani et al (2018) reported a similar result of a significant effect of MP on F% while non-significant effects on LAC%, and DE. In addition, Verma et al (2017) indicated that PRO% was significantly affected by MP. Besides, Brigitta and Gabriella (2013) revealed a significant effect of MP on NFS. Moreover Kuralkar & Kuralkar (2022) reported that MP affected F%, NFS%, and PRO%, while it did not affect LAC%. Crudeli et al (2004) reported that DE, PRO%, LAC%, and ash% were not affected while F% was affected by MP. The expected differences between the results obtained and other studies may be due to the different breeds, conditions of care, ages of buffaloes, and the statistical models used.

Table 1: Analysis of Variance for Some Components of Syrian Buffalo Milk.

Source of Variance	DF	Means of Squares					
		F (%)	PRO (%)	LAC (%)	NFS (%)	ASH (%)	DE×10^{-6} (g/cm^3)
PR	9	0.69^{NS}	0.11^{NS}	0.23^{NS}	1.35*	0.82^{NS}	1.21^{NS}
CM	6	4.01*	0.27*	0.50^{NS}	0.86^{NS}	0.55^{NS}	1.56^{NS}
MP	2	25.45**	0.03^{NS}	3.24**	0.28^{NS}	0.59^{NS}	19.36**
Residual	402	1.79	0.11	0.26	0.71	1.37	3.36
CV%		21.85	9.83	11.20	11.20	9.83	4.82

F (%), PRO (%), LAC (%), NFS (%), and ASH (%): percentages of fat, protein, lactose, non-fat solids, and Ash, respectively; DE: density of milk; PR: parity, CM: calving month, MP: Milk Production Period: Early (5 to 90 days), Middle (91 to 180 days), Late (above 181 days); *: P<0.05. **: P<0.01. Ns: insignificant effect. CV%: Coefficient of Variation.

Table (2) displays least-square means and standard errors of F%, PRO%, LAC%, NFS%, ash%, and DE in Syrian buffalo milk. The estimated milk component levels in Syrian buffaloes are lower than the averages reported in several references for various breeds raised under different care conditions. The values for F%, PRO%, LAC%, NFS%, Ash%, and DE, g/cm^3 from Kuralkar & Kuralkar (2022), Wangdi et al (2014), and Zeki et al (2013); Kuralkar & Kuralkar (2022), and Zeki et al (2013); Wangdi et al (2014), Bilal et al (2006), and Crudeli et al (2004); Kuralkar and Kuralkar (2022) and Wangdi et al (2014); Crudeli et al (2004); Ramya et al 2016 and Crudeli et al (2004), respectively, were found to be higher than the estimates in the current study. Therefore, enhancing the nutritional and healthcare of Syrian buffalo could potentially improve the milk components.

According to the effect of parity, there was no clear trend for trait values of milk components studied (Table 2). The range values were 0.48, 0.34, 0.33, 0.52, 0.022, and 0.002 for F%, PRO%, LAC%, NFS%, ash%, and DE, respectively. This suggests that by providing better herd care, milk quality may be improved by increasing its components.

No trend was found in values of NFS%, ash%, and DE according to the effect of calving month. On the other hand, F% was found to have increased from May to September (spring and summer), while both LAC% and PRO% decreased (Table 2); This may be due to the animals feeding large amounts of coarse feed (crop residue). The range values were 0.84, 0.20, 0.30, 0.35, 0.011, and 0.002 for F%, PRO%, LAC%, NFS%, ash%, and DE, respectively; Feeding balanced rations throughout the milking period may result in better milk content.

Table 2: Least-square Means ± Standard Errors of Percentages of Fat (F%), Protein (PRO%), Lactose (LAC%), Non-Fat Solids (NFS%), Ash% and Density of Milk, DE (g/cm^3)

Factors		**No.**	**F (%)**	**PRO (%)**	**LAC (%)**	**NFS (%)**	**Ash (%)**	**DE×10^{-6} (g/cm^3)**
μ		420	**6.13±0.19**	**3.41±0.05**	**4.36±0.07**	**8.57±0.12**	**0.77±0.01**	**1.027±0.0003**
Parity	1st	56	5.99±0.23	3.42±0.05^b	4.54±0.08^b	9.00±0.14	0.77±0.006	1.027±0.0003
	2nd	14	5.72±0.39	3.48±0.09^{ab}	4.56±0.15^b	8.64±0.24	0.75±0.010	1.026±0.0005
	3rd	28	5.70±0.28	3.45±0.07^{ab}	4.49±0.10^b	8.80±0.18	0.76±0.007	1.026±0.0004
	4th	70	5.79±0.18	3.39±0.04^b	4.57±0.07^b	8.99±0.11	0.77±0.005	1.026±0.0003
	5th	14	5.91±0.44	3.68±0.11^a	4.52±0.17^b	8.82±0.28	0.76±0.012	1.026±0.0006
	6th	14	6.13±0.40	3.35±0.10^{ab}	4.82±0.15^a	8.89±0.25	0.75±0.011	1.028±0.0005
	7th	70	6.17±0.22	3.37±0.05^b	4.67±0.08^{ab}	8.70±0.14	0.76±0.006	1.027±0.0003
	8th	42	5.75±0.24	3.42±0.06^b	4.64±0.09^b	8.75±0.15	0.76±0.006	1.027±0.0003
	9th	28	5.69±0.30	3.43±0.07^b	4.79±0.11^{ab}	8.69±0.19	0.76±0.008	1.027±0.0004
	10th	84	5.80±0.18	3.42±0.04^b	4.63±0.06^b	8.47±0.11	0.75±0.005	1.027±0.0003
Calving Month	3 ≥	14	5.45±0.40	3.52±0.10	4.67±0.15^{ab}	8.83±0.25	0.75±0.011	1.026±0.0005
	4th	84	5.72±0.18	3.58±0.04	4.81±0.07^a	8.65±0.11	0.76±0.005	1.027±0.0002
	5th	84	5.50±0.21	3.40±0.05	4.65±0.08^{ab}	8.89±0.13	0.76±0.005	1.027±0.0002
	6th	14	5.78±0.43	3.38±0.10	4.56±0.16^b	8.67±0.27	0.75±0.011	1.025±0.0005
	7th	42	6.11±0.24	3.38±0.06	4.57±0.09^{ab}	8.91±0.15	0.76±0.006	1.026±0.0003
	8th	42	6.19±0.27	3.39±0.06	4.59±0.10^{ab}	8.56±0.17	0.75±0.007	1.027±0.0003
	9 ≤	140	6.29±0.14	3.41±0.03	4.52±0.05^{ab}	8.90±0.08	0.77±0.003	1.025±0.0001
MP	Early	73	5.42±0.18^c	3.46±0.04	4.74±0.07^a	8.84±0.11	0.77±0.005	1.028±0.0003^a
	Middle	126	5.84±0.15^b	3.43±0.02	4.68±0.05^a	8.75±0.09	0.76±0.004	1.026±0.0002^b
	Late	221	6.33±0.12^a	3.43±0.03	4.45±0.04^c	8.74±0.08	0.76±0.003	1.026±0.0001^b

μ: Overall mean, $^{abcd.}$: Means in the same column without common letter are different at P<0.05. MP: Milk Period, Early (5 to 90 days), Middle (91 to 180 days), Late (above 181 days).

Trends in PRO%, LAC%, NFS%, Ash%, and DE were low, while F% increased with MP (Table 2). On the other hand, range values were 0.91, 0.03, 0.29, 0.10, 0.004, and 0.002 for F%, PRO%, LAC%, NFS%, ash%, and DE, respectively. Physiologically, milk production decreases as MP continues and is accompanied by an increase in F%. Accordingly, concentrated feeding is reduced as coarse forage increases in the diet, leading to an increase in F%.

The relationship between the hypothalamus and endocrine glands governs the animal physiological state, which is affected by the environment (Mushtaq and Qureshi, 2009). Feed quality and animal physiological conditions affect milk components (Neville et al 2001). The movement of milk components from the blood into udder tissues is under the control of multiple physiological factors and the genetic makeup of animals (Khan et al 2008). The differences between means of (PRO% and LAC%), (LAC%) and (F%, LAC%, DE (g/cm^3) were significant according to effects of parity, a month of calving, and milk period, respectively-using Duncan multiple range test. This confirms the importance of care and balanced nutrition to milk quality.

Table (3) shows that correlations were positive and highly significant between LAC% and each of PRO%, ash% and DE. Pandya et al (2017) showed a positive, highly significant correlation between LAC% and PRO% in Javarabadi buffaloes. Janmeda et al (2017) reported similar findings in buffaloes Surti and Jafferabadi. Regarding the relationship between LAC% and ash%, Choodamani et al (2018) reached a similar result. On the other hand, Tyagi et al (2016) reported non-significant correlations between LAC% and PRO% in Surti and Mohsani buffaloes. Furthermore, Choodamani et al (2018) identified a weak, negative, and non-significant correlation between NFS% and ash%, whereas there is a weak, non-significant correlation between PRO% and DE. In this study, some positive and highly significant correlations were observed. Based on the results of correlations between milk components, an increase in energy level in the herd diet may improve the quality of milk by increasing LAC%.

Table 3: Partial Correlation Coefficients from Error SSCP Matrix Prob.>|r| of Percentages of Fat (F%), Protein (PRO%), Lactose (LAC%), Non-fat solids (NFS%), and Ash%; and Density of Milk, DE (g/cm^3).

Milk components	F (%)	PRO (%)	LAC (%)	NFS (%)	ASH (%)
PRO (%)	0.015				
LAC (%)	-0.089	0.179**			
NFS (%)	0.021	-0.034	0.089		
ASH (%)	-0.039	0.033	0.202**	0.250**	
DE×10^{-6} (g/cm^3)	-0.035	0.101*	0.215**	0.044	0.057

SSCP: Sums of squares and cross products matrix; **: high significant; *: significant; No-sign: non-significant; D.F.= 402.

Conclusion

The milk quality could improve by providing better care and balanced feed throughout the milking period. Moreover, raising the energy level and coarse feed in the diet resulted in increasing milk content and improved LAC%, and F%, especially during the late milking period.

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